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# F/A-18E/F Built-in-test (BIT) Maturation Process

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ABSTRACT

Evaluations conducted by NAWCADPAX in 1996 and 1998 found that the newest F/A-18C airplanes had a BIT false alarm rates in excess of 88% and a mean flight hour between false alarm (MFHBFA) of less than 1 hour. The data provided by these evaluations resulted in significant changes to the F/A-18E/F BIT design and development, as a drastic reduction in false alarms was necessary to meet the BIT threshold requirements for Operational Evaluation (OPEVAL). At the end of development, the full systems configured F/A-18E/F airplane's MFHBFA was greater than 24 hours. This paper begins with a discussion of the cost associated with BIT false alarms. Next, this paper discusses the process implemented by the F/A-18E/F BIT Development Team that resulted in the F/A-18E/F airplane having superior BIT with a low false alarm rate. Many of the improvements have been incorporated into fleet F/A-18C airplanes. This process includes both engineering and BIT management solutions. In addition, this paper addresses the proposed approach that should be implemented to ensure that BIT remains a useful tool once implemented in the fleet. This approach includes engineering, management, and logistics solutions.

**BACKGROUND**

1. As documented in references (1) and (2), the F/A-18 airplane Built-in-test (BIT) performance has long been noted for high occurrences of false failure indications (BIT false alarms). BIT False alarms not only degrade maintainer confidence in BIT, they also degrade the pilot's confidence in determining the airplane's readiness for flight. Fleet users have adapted to this degraded level of BIT performance by essentially ignoring BIT and basing all maintenance on pilot observed and reported anomalies. This approach minimizes the effectiveness of the built-in redundancy and seriously increases the probability of mission aborts, accident or incident, and deviates from the prescribed maintenance concept. In order to ensure that the F/A-18E/F's BIT performance supported the needs of the fleet and would comply with the BIT false alarm requirements in the Operational Requirements Document (ORD), the F/A-18E/F BIT development and verification process required significant departure from those used previously. This updated BIT maturation process resulted in an F/A-18E/F with a BIT system that is far superior to any other aircraft currently in the fleet.

## COST OF BIT FALSE ALARMS

### General

2. The monetary costs associated with BIT false alarms are very high. However, monetary costs aren't the only costs. Fleet readiness and safety are impacted as well. In 1998 the Aviation Maintenance and Supply Readiness (AMSR) study group published a report containing specific issues relating to the high cost of ownership and reduced readiness of Navy aircraft. Among the issues listed were: depot workload, aircraft and engine shortfalls, high cannibalization rates, consumable material shortfalls, organizational and intermediate level maintenance manning, and high Aviation Depot Level Repair (AVDLR) cost, all of which results in higher Total Operating Costs. The 1997 Operational Advisory Group (OAG) listed BIT False Alarms as the number ten "War Fighting Degrader". In March of 1999, the F/A-18 System Safety Working Group (SSWG) Fleet Survey listed "lack of spare parts/cannibalization" and "squadron manning" as the top two fleet safety concerns. BIT False Alarms are a major contributor to the AMSR, OAG, and System Safety concerns.

### Man-hours and Aircraft Down Time

3. The fleet evaluations on F/A-18C airplanes revealed that 68% of all F/A-18C unscheduled maintenance was driven by BIT, and 75% of all cannot duplicate (CND) maintenance was caused by BIT false alarms. Table 1 summarizes F/A-18A/B/C/D organizational and intermediate level "wasted" (CND) maintenance expended during 1999. A total of 85,639 wasted man-hours were expended for a loss of over 46 man-years (using 1850 man-hours as a work year). These wasted maintenance man-hours can be directly related to the AMSR and System Safety concerns regarding squadron manning and maintenance workload. At a cost of $7.92 / flight hour, and over 220,000 flight hours/year, the annual wasted maintenance caused by BIT false alarms results in loss of over $1.7M. More importantly, the 46 man-years could have been expended on other work that would have resulted in improved readiness. As shown in Table 1, the elapsed maintenance time expended on wasted Organizational Level maintenance of 25,881 hours is equivalent to the loss of almost three aircraft for an entire year.

Table I
F/A-18A/B/C/D BIT Caused Wasted (CND) Maintenance

| | Wasted Maintenance Man-hours | Wasted Maintenance Man-years | Unnecessary Aircraft Downtime (Hours) | Unnecessary Aircraft Downtime (Years) |
|---|---|---|---|---|
| O-Level CND | 42,674 | 23.07 | 19,080 | 2.18 |
| O-Level Removal with I-Level CND | 15,482 | 8.37 | 6,801 | 0.78 |
| I-Level CND | 27,483 | 14.86 | N/A | N/A |
| Total | 85,639 | 46.30 | 25,881 | 2.96 |

Table Data Source: NALDA / ECA reports on all fleet F/A-18 airplanes from 1 March to 31 August 1999. Data was annualized (multiplied by two) and adjusted for BIT caused CND maintenance (multiplied by 0.75).

**<u>Non-quantifiable Costs</u>**

4. In addition to the quantifiable costs described above, there are other non-quantifiable costs associated with BIT False Alarms. For instance, replacing non-failed parts burdens the supply system, increases cannibalization, and degrades airplane readiness. Cannibalization impacts resulting from false removals are not included in the above calculations, but if they were, the results would only get worse. Intermediate and Depot Level CND items attributable to BIT caused removals result in un-quantifiable AVDLR costs. Every time a good weapons replaceable assembly is falsely removed from the aircraft, the squadron has to pay the associated AVDLR cost out of their operating budget. Another significant impact of high BIT false alarms is the loss of maintainer and pilot confidence in BIT, resulting in most BIT indications being ignored, even for valid failures. Flying with valid fault codes represents loss of system redundancy, decreases flight safety, and increases the probability of mission aborts.

**<u>Cost Conclusion</u>**

5. Far reaching (future) impacts of wasted maintenance include: retention of experienced personnel, developing expanded training, providing additional spare parts, increased AVDLR charges, and aircraft down time. In Naval Aviation's currently austere operating environment, the return on investment for minimizing false maintenance is substantial with long lasting improvements in Readiness, Manpower, Logistics and Safety.

**F/A-18E/F BIT PROCESS**

**<u>General</u>**

6. To ensure the BIT function in new equipment is useful to the fleet, it has to be considered in all phases of acquisition beginning with defining accurate and realistic design requirements

that relate to fleet needs. Strong BIT function engineering participation is essential through system design, development, and integration with attention to ensuring BIT is developed and integrated along with the operational hardware and software. Deficiencies found and corrected early enable more mature BIT software to enter flight-testing. During flight-testing, BIT has to be viewed as an operational mode and has to have the same priority as any other operational mode to ensure root cause and corrective actions for all deficiencies are determined and implemented in a timely manner. Throughout the flight test period, top-level management has to have visibility of BIT performance. Reports should present BIT status as compared to requirements, improvements from the last reporting period, and high drivers. The BIT effort does not end when development testing ends. It continues on to support fleet operations and identifies and corrects deficiencies caused by the fleet environment, verifies corrective action to previously discovered BIT problems, evaluates BIT performance of software and hardware upgrades, etc. Although all aspects of BIT specification requirements, design, development, and maintenance are important, the following discussion will be limited to the F/A-18E/F EMD flight test BIT maturation process and a proposed fleet support process.

## F/A-18E/F EMD Flight Test BIT Development Process

### BIT Management

7. Prior to the start of flight testing, a dedicated BIT Team comprised of Navy and Boeing members was implemented. The BIT Team researched and correlated the BIT requirements to actual fleet needs. Based on the fleet needs and operational scenarios, the BIT Team developed the "BIT Development/Evaluation Plan for F/A-18E/F Flight Test Program," reference (3). This Plan established the objectives of the BIT program; identified the data collection, analysis, scoring, and reporting processes; identified the anomaly reporting processes; and detailed the ground rules for data analysis and reporting.

8. Then, based on the BIT requirements, the BIT Team's objectives, and the fleet's needs, risk areas were identified and presented to Navy and Boeing F/A-18 Management. The BIT risks were tracked as a key performance parameter in the F/A-18E/F Air Vehicle Risk Management process. The BIT Team received excellent management backing, and all F/A-18 Integrated Product Teams (IPTs) understood the importance of BIT to their functional/operational parameters. This was a paradigm shift for many IPTs. Whenever a system was not meeting its individual requirement, Boeing Management required the team to track and report their progress towards meeting the required BIT performance. Without strong Navy and Boeing F/A-18 Management support, this effort would not have been as successful as it was.

9. Throughout the EMD flight test program, the BIT management team refined the ground rules as necessary, and provided the BIT status to both Navy and Boeing F/A-18E/F management. The status report included an assessment of the current status versus the BIT requirements, the predicted growth based on the projected (known and forthcoming) corrective actions. It also presented a summary of each integrated product team's performance, high drivers, status of deficiency reports including total, number open, number closed, and number with known corrective actions. BIT Management ensured that an emphasis was placed on characterizing and correcting all known BIT false alarms at the earliest opportunity.

## Ground Rules with OPTEVFOR

10. Because of the interrelationship between the ground rules used for Development Testing (DT), and the need to project the BIT performance into the fleet operational environment, meetings were held between the BIT Management Team and Commander, Operational Test and Evaluation Forces Atlantic, including representatives from the Operational Test Squadron (VX-9). These meetings served to inform the operational testers of the DT requirements, ground rules used to quantify these requirements, and interrelationships with Operational Testing (OT). The OT community shared most of their ground rules and evaluation processes to the extent that the BIT Management team was able to incorporate numerous changes to the DT BIT ground rules to enable reporting OT equivalent parameters. This process was very successful in that it provided OT BIT personnel with pre-evaluation experience of BIT functionality during DT, and enabled use of numerous DT Test Team procedures that would be applicable to their test. On future programs, we highly recommend DT and OT personnel corroborate in the development of ground rules for both DT and OT evaluations.

### DATA COLLECTION:

Maintenance Monitors

11. Boeing and the Navy assigned a team of approximately 22 maintenance knowledgeable supportability personnel to monitor the maintenance on all 7 EMD airplanes on a two-shift basis. Their task was to observe maintenance as it was performed and document maintenance relevant repair times, confirm accuracy of data elements on the contractors' maintenance documentation such as removed part numbers, serial numbers etc, and complete a Maintenance Monitor worksheet.

Maintenance Monitor Worksheet

12. The Monitor Worksheet was used to expand on items related to R&M, Supportability or BIT including identification of basic Navy related data elements, part replacement information, monitor comments and task time information. R&M and Supportability personnel as well as BIT engineers used the worksheet information to identify discrepancies, unique conditions, and to assist in accurate relevancy determination at R&M Review Boards or BIT Review Board (BRB) meetings. The Maintenance Monitor worksheet information was combined with the contractor's data and input to maintenance and BIT Data Files.

BIT Engineering

13. The eight member BIT Engineering Team was comprised of the Navy Reliability and Maintainability (R&M) Integrated Test Team (ITT) and the Boeing Mission Systems ITT. The Navy/Boeing team was responsible for coordinating all BIT data collection tasks including download of the recorded data from the airplane. The BIT Engineering Team correlated recorded BIT codes with maintenance performed, and assigned Fault Isolate and Detect (FID) codes identifying relevancy for fault detection, fault isolation, and false alarms. The recorded BIT data, maintenance data, and FID codes were maintained in the Aircraft Fault Reporting System (AFRS) database at Boeing. During weekly meetings, the R&M ITT and Mission Systems ITT,

along with the IPTs, reviewed and updated assigned FID codes, reviewed open anomaly reports, determined the need for new anomaly reports, and re-classified any corrected anomalies. This data was used by the BIT Management Team to calculate the reported BIT performance.

14. The Boeing Mission Systems ITT Members were the key members of the BIT Team. The BIT Team had many responsibilities, which included the following tasks.

a. Maintaining and updating the BIT database.

b. Assessing the BIT data to determine if there was a probable deficiency.

c. Coordinating BIT issues with the IPTs to expedite and enhance the resolution of BIT anomalies. The Mission Systems ITT members maintained excellent working relationships with all IPTs and was a key component of the success of the overall BIT evaluation.

d. Overseeing all BIT problem area investigations, testing, and subsequent development and implementation of corrective actions.

e. Maintaining a consolidated list of known BIT deficiencies as well as proposed corrective action.

**DIAGNOSTIC FILE FILTER (DFF)**

15. The F/A-18E/F has many avionics systems common the F/A-18C/D. The F/A-18C/D BIT evaluations of references (1) and (2) indicated that if the F/A-18E/F systems performed perfectly during Operational Testing, the common systems BIT false alarm performance would result in the FA-18/F not meeting the ORD false alarm percentage requirement of $\leq$ 45%. Since very few corrective actions could be implemented in the individual equipment, Boeing developed and implemented the Diagnostic File Filter (DFF).

16. The DFF is a database file loaded on the Memory Unit (MU) and subsequently uploaded to the Mission Computer at power-up. The DFF design task team included the problem equipment engineer, system safety, and an avionics integration engineer. A formal design document was created and routed for review and approval. The DFF was thoroughly tested in the Avionics Integration Lab and then presented to the Boeing Software Review Board for approval and incorporation in the aircraft. There were 12 releases of the DFF during EMD. The final release contained BIT filtering for fifty MSP codes, twenty-three of which were common to the F/A-18C/D.

17. The primary technique for filtering out false alarms while still retaining good detection capability was applying adequate persistence. The capability also exists to completely “turn off” a fault code or to selectively inhibit any unique periodic test within a subsystem from setting a fault code. Implementation of DFF rules to mitigate false alarms provided an excellent test of the effectiveness of the fix prior to final OFP implementation. Although intended as an interim fix for false alarm problems until an OFP solution could be implemented and released, in some cases, particularly older Government Furnished Equipment (GFE) systems, the DFF became the final solution. (Subsequent release to fleet F/A-18C airplanes has been implemented and in most DFF rules, the DFF serves as the final solution.)

18. The process of enabling and updating BIT rule base filters independently from the airplane OFP permits expeditious implementation of fixes with corresponding reduction in false alarm impacts. Future programs containing airplane Memory Units that can upload files to the Mission Computer should consider incorporating a DFF function.

## FINAL TECHEVAL RESULTS

19. The overall F/A-18E/F BIT performance during EMD is presented in table 1.

TABLE 1

| BIT Parameter | Requirement (1) | TECHEVAL | EMD (ALL) |
|---|---|---|---|
| PFD | 65% / (85%) | 99.0% | 97.9% |
| PFI | 85% / (90%) | 99.5% | 99.6% |
| PFA | 45% / (25%) | 16.0% | 8.2% |
| MFHBFA (2) | 7.4 (Calculated) | 24.2 | 52.7 |

(1) Reference (4) requirement for OPEVAL is shown first with TECHEVAL requirements in parenthesis. TECHEVAL RQMTS were for new and significantly modified equipment (Category 1). There was no overall Aircraft Level BIT requirement for TECHEVAL because of the mix of new (Category 1) and existing (legacy) equipment. The values shown for TECHEVAL are presented at the overall airplane level.
(2) There was no MFHBFA requirement. The MFHBFA value was calculated using a Boeing developed formula based on a PFA of 45%, and predicted levels of reliability. The result was a MFHBFA of 7.4.

**Fault Detection and Isolation Performance**

20. As shown in Table 1, the PFD and PFI performance of the F/A-18E/F during both EMD (all) and TECHEVAL of greater than 97.9% was outstanding. This included legacy systems whose PFD and PFI were very good as well. Although design discrepancies were effectively eliminated during vendor integration testing prior to airplane installation, as discussed later in this report, the systems had numerous false alarms after installation in the airplane. Laboratory testing was effective for fault detection and isolation maturation, but was not effective for false alarm maturation because of the inability to replicate the actual airplane integration environment.

21. The equipment having the most Detection and Isolation mitigation development efforts outside of the laboratory were systems containing mechanical equipment interfaces such as Environmental Control, Flight Control and Fuel. Characterizing BIT indications on these systems were the most difficult to validate and eliminate, primarily because corrective action was often related to adjustments within software algorithms monitoring hardware and various functional performance attributes such as pressure, temperature or strain, rather than a straightforward software implementation.

**Bit False Alarm Performance**

Legacy F/A-18C False Alarms

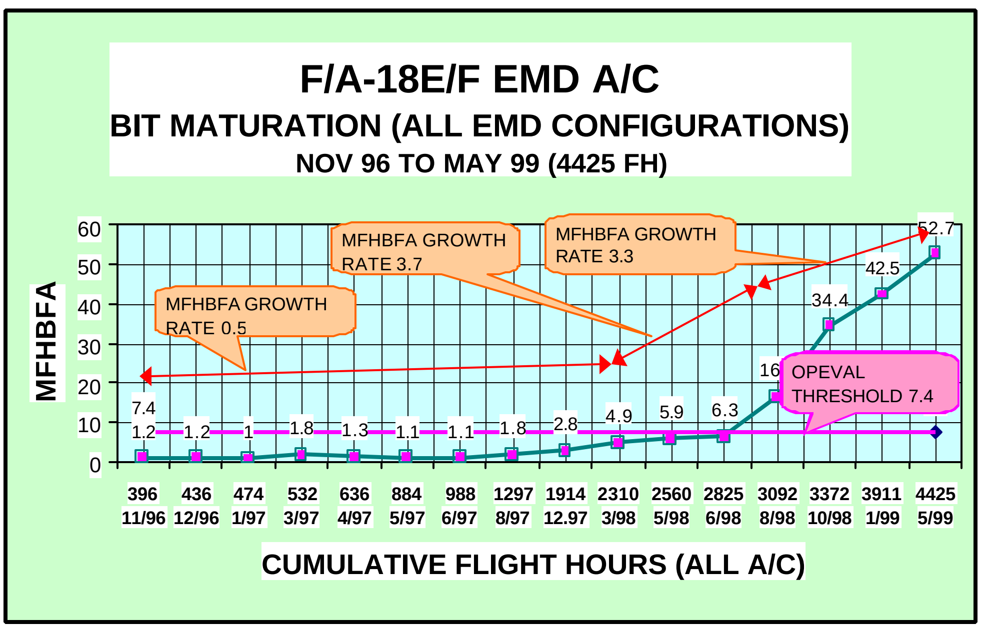
22. The benefits of performing the two fleet BIT evaluations were significant, particularly with Boeing participation that would confirm the poor BIT False Alarm performance in their

newest production product. The evaluations provided exceptional statistically significant R&M and BIT values because of the high flight rate and equipment utilization in the actual mission environment. Investigations conducted as a result of these evaluations resulted in fixes that were incorporated in the F/A-18E/F and later retrofitted into the F/A-18C airplanes through incorporation of the DFF function. The process used to characterize BIT performance of legacy equipment in a fleet environment was highly effective and should be implemented in similar programs.

**Combined Equipment BIT Performance Growth**

23. As shown in Figure 1, the MFHBFA growth rate was very slow for the first year of EMD. The primary factor was the continuing process of identifying false alarm problems, developing and testing the proposed fix, and implementation of the fix in the appropriate Operational Flight Program (OFP). The term 'appropriate' OFP refers to implementation in either the parent system OFP or the Mission Computer OFP. Usually the parent system OFP change was developed and implemented by the supplier of the system whereas Mission Computer OFP changes were a Boeing responsibility. Phase in of these false alarm fixes to the airplanes were schedule dependent where the next scheduled release of the OFP may not occur for months, or even years, resulting in implementation delays, and slower growth rates.

FIGURE 1

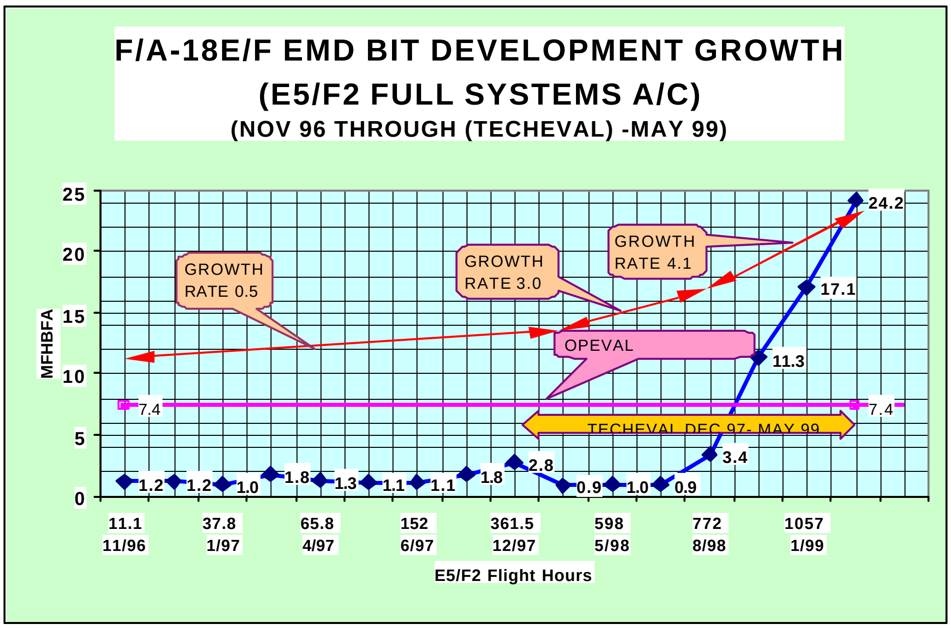



24. Another factor effecting the MFHBFA growth rate was the percentage of BIT functionality that was turned on during the initial phase of EMD. The approach used by some of the more complex subsystems was to activate only a portion of the BIT tests during the beginning of flight testing. As work continued to eliminate problems found with these initial tests, more tests would be activated, corrected, etc, until all the BIT tests were turned on, evaluated and corrected. As a result, sequential activation of more BIT tests effected the overall

growth rate. At times, growth was negative because of the problems found with newly activated tests or newly installed systems offset the improvements. Figure 3 shows the EMD history of problems identified and solutions incorporated to resolve over 5300 false alarms. Note the initial period of EMD where the solutions plot coincides with the growth shown in figures 1and 2.

25. EMD equipment configurations also effected overall airplane BIT growth. Installation and operation of mission systems related equipment was phased in during the EMD flight test program. Newly identified integration anomalies resulted in more false alarms to fix. Each delivered airplane had slightly different configurations, and each presented unique integration issues that had to be dealt with. In terms of MFHBFA growth, the full systems airplanes (E5 and F2) shown in Figure 2 depicts the most accurate view of total aircraft MFHBFA growth.

FIGURE 2



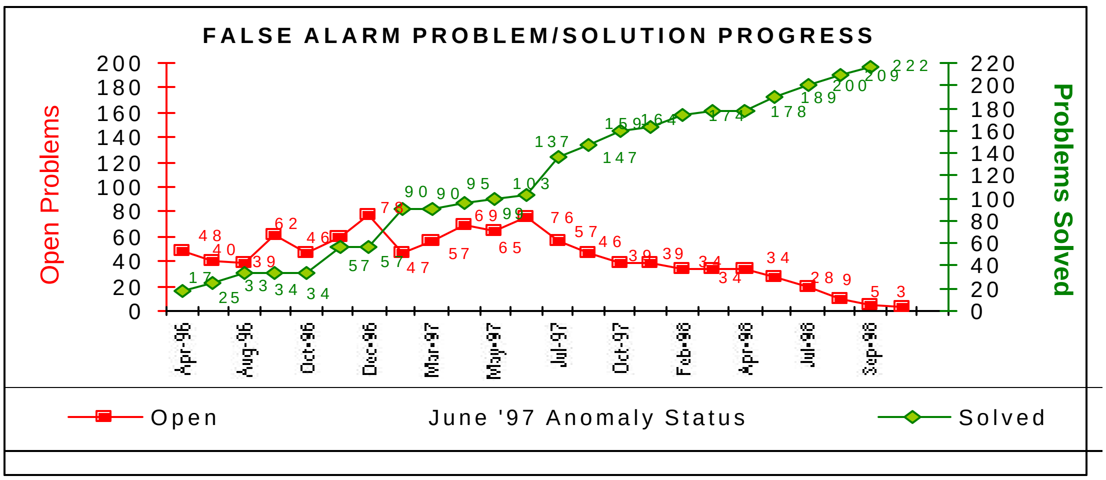

**Overall Airplane MFHBFA Growth**

26. As discussed in the preceding paragraphs, MFHBFA growth shown in Figure 2 for TECHEVAL appeared very slow to show improvement even though numerous fixes were being incorporated. It should be noted that at the overall airplane level, the growth rate of 0.5 was calculated for the first year and a half of EMD. Then, in the last year, a rapid increase was noted at a growth rate of 3.0 to 4.1 as all the false alarm problems were resolved so that the demonstrated growth reflects accumulation of flight hours without new false alarms. The approach taken by the BIT team was to fix every false alarm that could be characterized. In that way, the remaining false alarms occurred so infrequently, that squadron readiness and maintenance would not be impacted.

27. It is recognized that in the fleet environment, true intermittent failures would be viewed as false alarms until such time the occurrences ware persistent enough to merit troubleshooting and corrective action. The cumulative total of intermittent failures combined with the minimized

false alarms can be referred to as the "floor level" of false alarm performance. It is the test team's opinion that the TECHEVAL MFHBFA of 24.2 is the F/A-18E/F "floor level" of false alarm performance in a test environment. It is also considered to be the best the airplane can ever achieve given the test environment, airplane configurations and non-fleet representative missions. This representation was confirmed during the Operational Evaluation (OPEVAL) that concluded the MFHBFA was around 11.0 using different fleet related operational rules and grading criteria. The goal of the test team was to achieve a MFHBFA high enough to meet the OPEVAL threshold, even though the ground rules would be different. We concluded that the BIT development program was confirmed by OPEVAL as successful. Future programs should adopt similar processes and procedures to develop the BIT system in complex airplanes.

Figure 3
BIT False Alarm Problems and Solutions




## F/A-18E/F BIT FLEET SUPPORT

28. Following major weapons system EMD, numerous BIT hardware and software changes are incorporated into the Low Rate Initial Production (LRIP) aircraft prior to or concurrent with fleet delivery. Few of these changes are evaluated as to effectiveness, and overall impact on the fleet. For newly introduced LRIP equipment, there is no process in place to mature the BIT function as was done during EMD. Therefore, many of the integration issues discovered during the initial development process will reappear without the engineering disciplines and ITT support needed to resolve them. Should false alarms be evident, the resulting impact would degrade maintenance, aircraft availability, and mission effectiveness. Much of the return on investment gained by an aggressive BIT Maturation effort during EMD might be negated by the lack of a follow-on effort to monitor and refine BIT functionality.

### Future Weapon System Upgrades Drive BIT Support Requirements

29. Technological improvements in digital equipment have enabled significant gains in weapon system capability. Current airplane upgrade programs are fulfilling the need to achieve these gains in technology and to increase capabilities. The resulting equipment upgrades are

referred to as ‘roadmap’ items that will drive a need for BIT Functional Area Support for years to come. The most appropriate location for the BIT Management Team would be part of the Air Vehicle Management Team since it crosses all other functional areas within the airplane.

**Air Vehicle BIT Management**

30. The F/A-18E/F Air Vehicle BIT Management Team would have the responsibility of extending the tasks of the EMD BIT Management Team. These tasks include assessment, analysis of problem areas, coordination of investigations, development and implementation of corrective action. They would coordinate BIT issues with Fleet Introduction Teams (FIT), and report progress to appropriate engineering and logistic disciplines.

**BIT Status Reports**

31. The Air Vehicle BIT Management Team would consolidate all BIT related data including Software Anomaly Reports / Software Trouble Reports (SAR/STR) that identify fault detect, fault isolate, and false alarm anomalies, proposed corrective actions, etc. and other appropriate data provided by ITT and Road Map Teams. Individual equipment performance and rolled-up aircraft Lot data will be presented. The owners of discrepant systems will periodically present plans of action and milestones for the closing out of their BIT related SARs/STRs.

**BIT Engineering**

<u>Software Configuration Set (SCS) Validation &Verification V&V) at China Lake</u>

32. A BIT engineering position should be established at the Weapons System Support Activity, China Lake, Ca.. The equipment IPTs would handle BIT issues. However, BIT fixes compete with the cost of other problem resolutions or system enhancements and therefore usually get a low priority regardless of the adverse impact to fleet readiness. Currently there is no process for consolidation and documentation of the BIT deficiencies resident within new Software Configuration Sets (SCS) that are sent to the fleet. The BIT engineer would provide the coordination of all BIT related tasks including:

a. Coordinate BIT issues with the IPTs to expedite and enhance the resolution of BIT anomalies. Oversee all BIT problem area investigations, testing, and subsequent development and implementation of corrective actions. The BIT engineer will attend pertinent SCS meetings including Software Change Review Boards, SAR meetings, etc.

b. Investigate and recommend the best method for BIT corrective action implementation, for example: system OFP, M/C SCS, DFF, debrief procedures, maintenance publications, etc.

c. Provide a consolidated list of known BIT deficiencies as well as corrective actions contained within each SCS load released to the fleet.

d. The BIT Engineer will conduct aircraft level BIT evaluations during SCS V&V.

e. Data collection will include monitoring SCS development flights, attending pilot brief/debriefs, and downloaded AMU BIT files. The BIT engineer will then enter appropriate BIT data into the BIT database. The BIT Engineer will coordinate any BIT anomalies with the appropriate IPT and will assist in writing any associated SARs/STRs.

Fleet Evaluations/Coordination:

33. Once systems are fielded, the current approach requires fragmented IPT funding which is often underestimated based on the levels of BIT problems the system is experiencing. There is no process in place to assess BIT performance in equipment once delivered to the fleet. The proposed method that is the most cost effective and technically productive is to assess fleet BIT performance through periodic technical evaluations. The effort should follow the E/F EMD BIT ground rules that would permit identification of problem areas. The problems should be investigated and the cause of the high driver fault codes should be identified by origination of STRs/SARs. Issues would be coordinated with the China Lake BIT engineer and roadmap IPT's to resolve BIT anomalies.

BIT Problems with Logistics Fixes

34. To maintain the BIT performance in the fleet, there may be logistics solutions to BIT integration deficiencies. These solutions include maintenance training, additional BIT documentation, and reference material. The tasks would continue throughout the life cycle as long as new equipment and software is introduced into the airplane, and corrective action is slow to be implemented.

a. Train maintenance (control) personnel to TREND BIT indications to better recognize true versus false BIT indications (until BIT false alarms are fixed). Interface with Optimized NALCOMIS developers to include an autonomous BIT TRENDING function using the Automated Maintenance Environment (AME) equipment.
b. Develop an in-depth Naval Aviation Maintenance Training Group (NAMTRAGRU) course on F/A-18 A-F BIT Integration. Maintenance Personnel need more detailed information to troubleshoot BIT indications than what is provided in normal NAVAIR series manuals, particularly when BIT has such a high level of false alarms.
c. Develop a maintenance "Gray Book" containing detailed BIT logic defining what it takes to set each Maintenance Status Panel (MSP) code, Caution, Warning, or Advisory. Frequently, BIT indications are considered false because post flight maintenance fails to replicate the fault code. If the conditions necessary to set the code were known, the maintainer might have correctly identified the real failed component the first time out, rather than after numerous flights and man-hours spent needlessly 'shot-gunning' components. The Gray Book would complement current maintenance instructions with detailed information compiled from software logic and flow diagrams. The Gray Book information should be incorporated in the current electronic media.
d. Develop a list of "Known False Alarms" to complement the trending data analysis to enhance task assignment by maintenance control.

## CONCLUSIONS

35. Complex weapon system diagnostics engineering support teams are essential to meeting the Navy's operational and logistic support goals. Implementation of a totally integrated Navy/Contractor BIT support team throughout the life cycle of the weapon system is highly effective and provides significant return on investment through lower life cycle costs, improved readiness, safety and mission effectiveness.

## RECOMMENDATIONS

36. For all complex weapons systems having sophisticated integration and diagnostics functions, a BIT Engineering Support Team should be developed prior to the beginning of EMD and sustained throughout the life cycle of the platform.

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BIOGRAPHY

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David Orwig is a Senior Engineering Technician supporting the Naval Air Warfare Center Aircraft Division TACAIR Reliability and Maintainability Department (AIR 4.1.6.1) at Patuxent River, Maryland. He currently provides integrated diagnostic system design, development, test and evaluation Contractor Support Services for the F/A-18A-F, Joint Strike Fighter and V-22 aircraft weapons systems. He also provides consultation services for the H-1 Upgrade and various other new development programs. Prior to his current assignment, he was the Department Head, Reliability, Maintainability, and System Safety for STRIKE Aircraft Test Directorate, Patuxent River, MD. Mr. Orwig was the Lead R&M engineer for the F/A-18A/B development program, and contributed significantly to the development of requirements, and evaluation processes for the F/A-18E/F Engineering Development program. His 47-year background in Naval Aviation includes 21 years Naval service and over 26 years in new system acquisition, design, development, test and evaluation. He has contributed to numerous technical reports and papers on R&M and Integrated Diagnostics of new weapons systems.